Abstract

Multiple users compete for a common resource like bandwidth to communicate data in interference networks. Existing approaches in dealing with interference limit the rate of communication due to paucity of shared resources. This limitation in the rate gets more glaring as the number of users in the network increases. For example, existing wireless systems either choose to orthogonalize the users (for example, Frequency Division Multiple Access (FDMA) systems or Code Division Multiple Access (CDMA) systems) or treat interference as Gaussian noise at the receivers. It is well known that these approaches are sub-optimal in general. Orthogonalization of users limit the number of available interference-free channels (known as degrees of freedom, abbreviated as DoF) and treating interference as noise means that the receiver cannot make use of the structure in the interfering signals. This motivates the need to analyze alternate transmit and decoding schemes in interference networks.

This thesis mainly analyzes transmit schemes that use linear precoding for various configurations of interference networks with some practical constraints imposed by the use of finite input constellations, propagation delays, and channel state availability at the transmitters. The main contributions of this thesis are listed below.

Achievable rates using precoding with finite constellation inputs in Gaussian Interference Channels (GIC) is analyzed. A metric for finding the approximate angle of rotation to maximally enlarge the Constellation Constrained (CC) capacity of two-user Gaussian Strong Interference Channel (GSIC) is proposed. Even as the Gaussian alphabet FDMA rate curve touches the capacity curve of the GSIC, with both the users using the same finite constellation, we show that the CC FDMA rate curve lies strictly inside the CC capacity curve at high powers. For a

K-user MIMO GIC, a set of necessary and sufficient conditions on the precoders under which the mutual information between between relevant transmit-receive pairs saturate like in the single user case is derived. Gradient-ascent based algorithms to optimize the sum-rate achieved by precoding with finite constellation inputs and treating interference as noise are proposed.

For a class of Gaussian interference networks with general message demands, identified as symmetrically connected interference networks, the expected sum-spectral efficiency (in bits/sec/Hz) is shown to grow linearly with the number of transmitters at finite SNR, using a time-domain Interference Alignment (IA) scheme in the presence of line of sight (LOS) channels.

For a 2×2 MIMO X-Network with M antennas at each node, we identify space-time block codes that could be coupled with an appropriate precoding scheme to achieve the maximum possible sum-DoF of $\frac{4M}{3}$, for $M = 3, 4$. The proposed schemes are shown to achieve a diversity gain of M with SNR-independent finite constellation inputs. The proposed schemes have lower CSIT requirements compared to existing schemes.

This thesis also makes an attempt to guarantee a minimum throughput when the zero-interference conditions cannot be satisfied in a wireline network with three unicast sessions with delays, using Precoding Based Network Alignment (PBNA). Three different PBNA schemes namely PBNA with time-varying local encoding coefficients (LECs), PBNA using transform approach and time-invariant LECs, and PBNA using transform approach and block time-varying LECs are proposed and their feasibility conditions analyzed.